

Hydraulics

<u>3rd Year civil</u>

<u>First Term (2009 - 2010)</u>

Chapter (   )

2009 - 2010

Specific Energy

1- If a uniform critical flow is occurs in a best rectangular open channel of 5.00m width what would be the canal slope if n = 0.015.

2- A discharge of 500 c.f.s is carried by a trapezoidal canal of 10.00 ft bed width and side slope 1:1, evaluate Froude number when the specific energy is 8.70 ft.

3- A discharge of 40 m3/sec is flowing in a rectangular section of bde width 10.00 m and bed slope 10 cm/km, if the Manning coefficient in this canal is 0.025, determine

a- The normal water depth

b- Critical depth, critical velocity, and critical slope

c- Normal depth if the critical depth is 2.00m

4- A rectangular flume of n = 0.012 is laid at a slope of 0.0036 and carries a discharge of 580 c.f.s for critical flow conditions what width is required.

5- A uniform flow of 20.00 m3/sec occurs in a rectangular channel of 5.00 m bed width , a smooth hump of 0.50 m is placed in the canal, if the section is hydraulically best it is required to

a- The difference in the water level before and at the hump

b- The height of the hump to produce critical water depth on it, and the drop in water level

c- Draw the relation between y1,y2 and Δz

d- What is the effect of increasing the height of the hump to 1.00 m on the water level.

بسم الله الرحمن الرحيم

Specific Energy

Q(1):

- $n = 0.015$
- sec. is B.H.S

5.0m

Req.: $S = ??$

sol.:

$$\because Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

for B.H.S $B = 2y$

$$\therefore y = \frac{5}{2} = 2.50m$$

$$\because A = b \cdot y = 5 \times 2.5 = 12.5 m^2$$

$$P = b + 2y = 5 + 2 \times 2.5 = 10m$$

for critical flow $y = y_c$

$$\because y_c = \sqrt[3]{q^2/g}$$

$$\therefore 2.5 = \sqrt[3]{q^2/9.81}$$

$\therefore q = 12.4 \ m^3/s/m'$

$\therefore Q = q \times b = 12.4 \times 5 = 62 \ m^3/s$

$$\therefore 62 = \frac{1}{0.015} \times \frac{(12.5)^{5/3}}{(10)^{2/3}} \times (S)^{1/2}$$

$$\therefore S = 4.11 \times 10^{-3} \ \#$$

Q(2):

$Q = 500 \ ft^3/sec.$

$E = 8.7 \ ft.$

1:1

10.0 ft

Req.: $F_n = ??$

sol.:

$$\therefore F_n = \frac{V}{\sqrt{g \cdot y_h}}$$

$$\because E = y + \frac{Q^2}{2gA^2}$$

OR $$E = y + \frac{V^2}{2g}$$

} specific energy equation

$\therefore \quad A = (b + Zy)\,y = (10 + 1 \times y)\,y = 10y + y^2$

$$\therefore \quad 8.7 = y + \frac{(500)^2}{2 \times 32.2 \times (10y + y^2)^2}$$

$$8.7 = y + \frac{3882}{(10y + y^2)^2}$$

by trial

y	6	8	8.5		2.0	
R.H.S	6.42	8.18	8.66		8.73	

$$y = 8.5 \text{ ft}$$

$\therefore \quad A = (10 + 1 \times 8.5) \times 8.5 = 157.25 \text{ ft}^2$

$$\therefore \quad V = \frac{Q}{A} = \frac{500}{157.25} = 3.2 \text{ ft/sec.}$$

$$\because \quad F_n = \frac{V}{\sqrt{g \cdot y_h}}$$

$$y_h = \frac{A}{T} = \frac{157.25}{\underset{(b + 2Zy)}{(10 + 2 \times 1 \times 8.5)}} = 5.82 \text{ ft}$$

$$\therefore \quad F_n = \frac{3.2}{\sqrt{32.2 \times 5.82}} = 0.233$$

ملحوظة

نظراً لأنه يوجد جذرين حقيقيين لمعادلة الطاقة النوعية نجد أنه اثناء حل المعادلة عكس الحصول على أن قيمة $y = 2\ ft.$ وعليه

$$A = (10 + 1 \times 2) \times 2 = 24\ ft^2$$

$$T = (10 + 2 \times 1 \times 2) = 14\ ft.$$

$$y_h = \frac{24}{14} = 1.71\ ft.$$

$$V = \frac{500}{24} = 20.83\ ft/sec.$$

$$\therefore\ F_n = \frac{20.83}{\sqrt{32.2 \times 1.71}} = 2.70$$

وهذا يوضح الآتى

y
8.5
$y_c = 2.5$
2.0
8.7
E

Q(3):

- $Q = 40\ m^3/s$
- $S = 10\ cm/km$
- $b = 10\ m$
- $\frac{1}{n} = 40$

y

$b = 10m$

Req.: a- $y = ??$

b- y_c , V_c , S_c

c- $y = ??$ at $y_c = 2.0m$

Sol.:

a- $$Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$$A = b.y = 10y$$

$$P = b + 2y = 10 + 2y$$

$$\therefore 40 = 40 \times \frac{(10y)^{5/3}}{(10+2y)^{2/3}} \times (10 \times 10^{-5})^{1/2}$$

$$\therefore \quad 100 = \frac{(10y)^{5/3}}{(10+2y)^{2/3}} \quad \text{by trial}$$

y	3	5	5.3	5.33	
R.H.S	45.6	92.1	99.5	100.2	

$$y \simeq 5.32 \ m \ \#$$

b -

$$y_c = \sqrt[3]{q^2/g}$$

$$q = \frac{Q}{B} = \frac{40}{10} = 4 \ m^3/s/m'$$

$$y_c = \sqrt[3]{\frac{(4)^2}{9.81}} = 1.18 \ m \ \#$$

$$\because Q = A_c \times V_c$$

$$40 = (10 \times 1.18) \times V_c$$

$$\therefore V_c = 3.39 \ m/s \ \#$$

$$\because Q = \frac{1}{n} \cdot \frac{A_c^{5/3}}{P_c^{2/3}} \cdot S^{1/2}$$

$$A_c = 10 \times 1.18 = 11.8 \ m^2$$

$$P_c = 10 + 2 \times 1.18 = 12.36 \ m$$

$$\therefore \quad 40 = 40 \times \frac{(11.8)^{5/3}}{(12.36)^{2/3}} \times S_c^{1/2}$$

$$S_c = 7.6 \times 10^{-3} \quad \#$$

C-

$\because \; y_c = 2.0\,m \quad \Rightarrow \quad y = ??$

$\because \; Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$

$\because \; A = 10y \quad , \quad P = 10 + 2y$

$S = 10\,cm/km \quad , \quad 1/n = 40$

for $y_c = 2.0\,m$

$\because \; y_c = \sqrt[3]{q^2/g} \quad \Rightarrow \quad y_c^3 = \frac{q^2}{g}$

$\therefore \; q^2 = y_c^3 \cdot g = (2)^3 \times 9.81$

$q = 8.86 \; m^3/s/m'$

$Q = q \times b = 8.86 \times 10$

$Q = 88.6 \; m^3/s$

$$\therefore 88.6 = 40 \times \frac{(10y)^{5/3}}{(10+2y)^{2/3}} \times (10 \times 10^{-5})^{1/2}$$

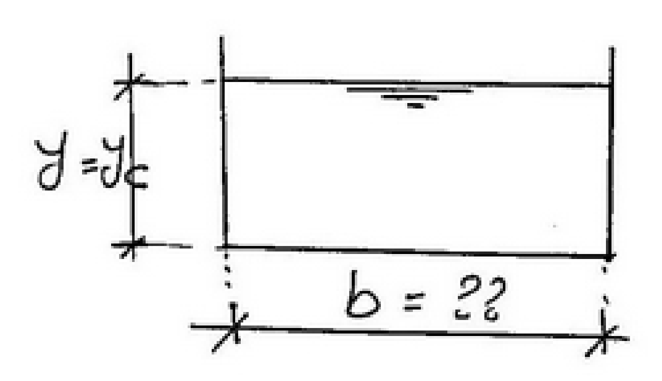
$$221.5 = \frac{(10y)^{5/3}}{(10+2y)^{2/3}} \quad \text{by trial}$$

y	8	9	10	9.95
R.H.S	169.2	196	223.1	221.7

$$y \simeq 9.95 \text{ m} \ \#$$

Q(4):

- $n = 0.012$
- $S = 0.0036$
- $Q = 580 \ ft^3/s$



Req.: for critical flow condition

$b = ??$

Sol.:

$$\because Q = \frac{1.486}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$\because\ A = b \cdot y_c \quad , \quad P = b + 2y_c$

$$\therefore\ 580 = \frac{1.486}{0.012} \times \frac{(b \cdot y_c)^{5/3}}{(b+2y_c)^{2/3}} \times (0.0036)^{1/2}$$

$$78.1 = \frac{(b \cdot y_c)^{5/3}}{(b+2y_c)^{2/3}} \longrightarrow \boxed{1}$$

$$\because\ y_c^3 = \frac{q^2}{g} = \frac{Q^2}{b^2 \cdot g}$$

$$y_c^3 = \frac{(580)^2}{32.2\ b^2} = \frac{10447.2}{b^2}$$

$$\therefore\ y = \frac{21.86}{b^{2/3}} \longrightarrow \boxed{2}$$

from $\boxed{2}$ in $\boxed{1}$

$$\therefore\ 78.1 = \frac{\left[b \times \frac{21.86}{b^{2/3}}\right]^{5/3}}{\left[b + \frac{2 \times 21.86}{b^{2/3}}\right]^{2/3}}$$

$$\therefore\ 78.1 = \frac{\left[21.86\ b^{1/3}\right]^{5/3}}{\left[b + \frac{43.72}{b^{2/3}}\right]^{2/3}}$$

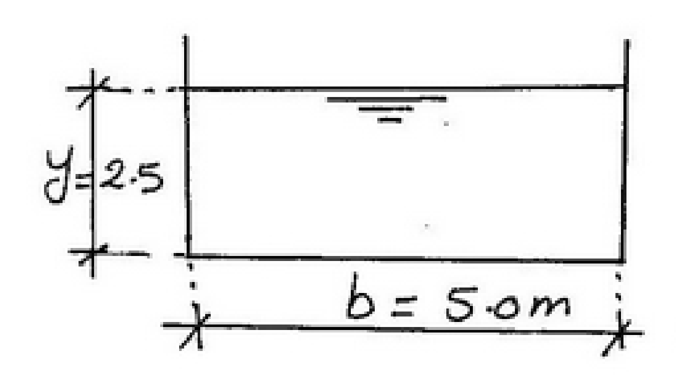
Solve by trial

b	3	5	7	7.5	8.0	8.5
R.H.S	37.8	56.8	70.9	73.7	76	78.9

$y \simeq 8.4$ ft #

Q(5) :

- $Q = 20\ m^3/s$
- $b = 5.0\ m$
- sec. is B.H.S
- $\Delta Z = 0.50\ m$



Req. :

a- $\Delta y = ?$ befor and after the hump

$\Delta Z = 0.50$

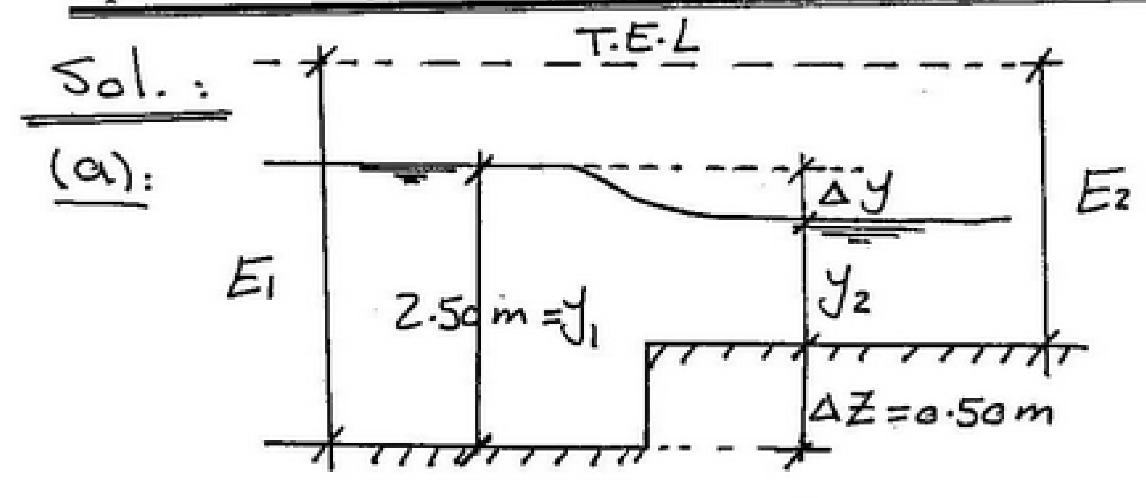
b- $\Delta Z = ?$ $\Rightarrow y_2 = y_c$, Δy

c- $\Delta Z = 1.0\ m$ effect on water depth

d- draw y_1, y_2 v.s. ΔZ

Sol.:

(a):

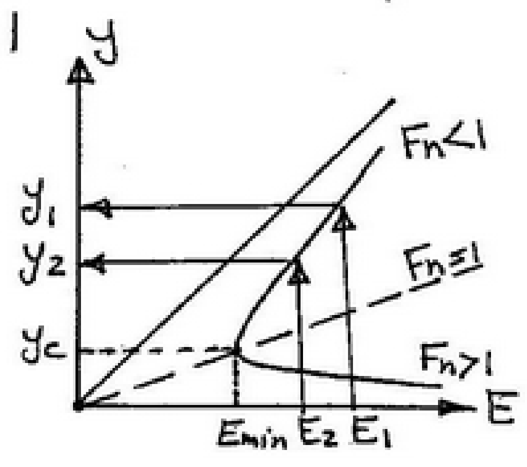


$$\because E_1 = E_2 + \Delta Z$$

$$\because F_n = \frac{V}{\sqrt{g \cdot y}}$$

$$\because V = \frac{Q}{A} = \frac{20}{(5 \times 2.5)} = 1.60 \text{ m/s}$$

$$\therefore F_n = \frac{1.6}{\sqrt{9.81 \times 2.5}} = 0.32 < 1$$



من منحنى الطاقة نجد أنه مع وجود عتبة
في مسار جريان له $F_n < 1$
يسبب انخفاض عمق الماء فوق العتبة

$$\therefore y_1 = y_2 + \Delta Z + \Delta y$$

$$\because E_1 = E_2 + \Delta Z$$

$$\therefore \quad y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gA_2^2} + \Delta Z$$

$A_1 = 5 \times 2.5 = 12.50 \, m^2$

$A_2 = 5 y_2$

$$\therefore \; 2.5 + \frac{(20)^2}{2 \times 9.81 \times 12.5^2} = y_2 + \frac{(20)^2}{2 \times 9.81 \times (5y_2)^2} + 0.5$$

$$\therefore \; 2.63 = y_2 + \frac{0.82}{y_2^2} + 0.5$$

$$\therefore \; 2.13 = y_2 + \frac{0.82}{y_2^2} \quad \text{by trial}$$

بملاحظة منحنى الطاقة

نجد أن قيمة y_2 محصورة بين y_c ، y_1 وعليه

يمكن حساب قيمة y_c لتحديد حدود التعويض

$$y_c = \sqrt[3]{q^2/g} = \sqrt{\frac{(20/5)^2}{9.81}} = 1.18 \, m$$

$$1.18 < y_2 < 2.5$$

y_2	2	1.9			
R.H.S	2.21	2.13			

$y_2 = 1.90 \, m$

$\therefore \; 2.5 = 0.5 + 1.9 + \Delta y$

$\Delta y = 0.10 \; m$ #

(b)

Δy

$y_1 = 2.50$

$y_2 = y_c$

$\Delta Z = ??$

$\therefore \; E_1 = E_2 + \Delta Z$

for $y_2 = y_c \Rightarrow E_2 = E_{min} = 1.5 y_c$

$\therefore \; y_c = 1.18 \; m$

(لأن المقطع مستطيل) $\therefore \; E_2 = E_{min} = 1.5 y_c = 1.5 \times 1.18$

$E_2 = 1.77 \; m$

$\therefore \; 2.63 = 1.77 + \Delta Z$

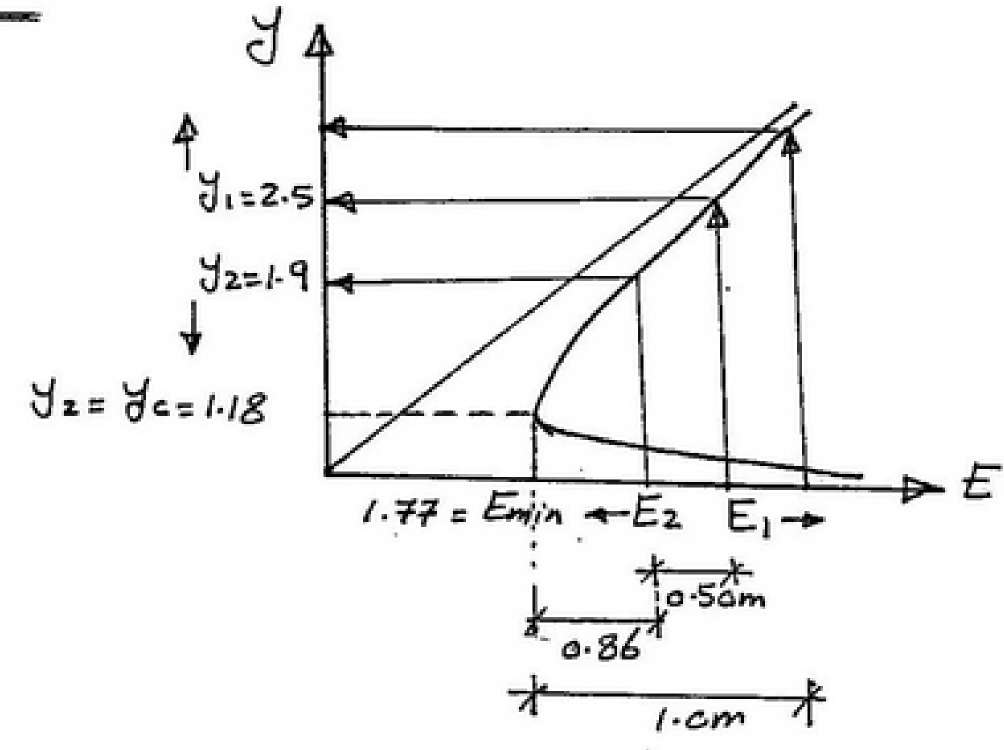
$\therefore \; \Delta Z = 0.86 \; m$ #

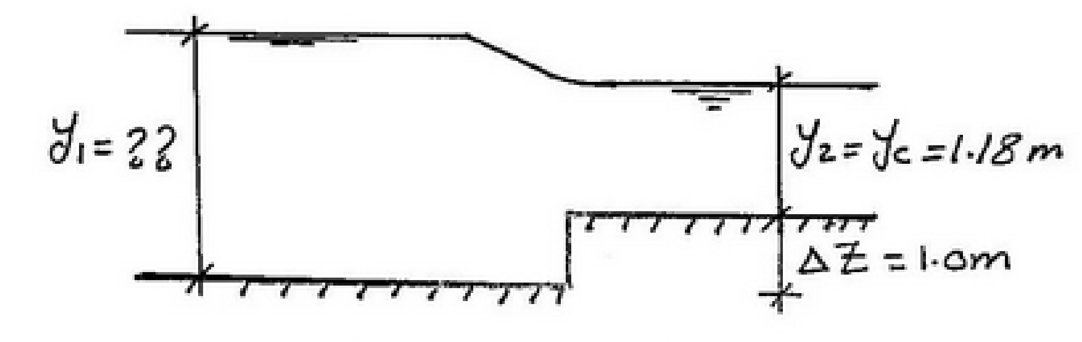
$\because \; y_1 = y_2 + \Delta Z + \Delta y$

$2.5 = 1.18 + 0.86 + \Delta y$

$\Delta y = 0.46 \; m$ #







$$\therefore E_1 = E_2 + \Delta Z$$

$$y_1 + \frac{Q^2}{2gA_1^2} = 1.77 + 1.0$$

$$\therefore y_1 + \frac{(20)^2}{2 \times 9.81 \times (5y_2)^2} = 2.77$$

$$\therefore y_1 + \frac{0.82}{y_1^2} = 2.77$$

y_1	2.6	2.65		
R.H.S	2.72	2.77		

$y_1 = 2.65$ m #

(d)

